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Impact of Preexisting Left Bundle Branch Block in Transcatheter Aortic Valve Replacement Recipients

Fischer, Quentin ; Himbert, Dominique ; Webb, John G ; Eltchaninoff, Helene ; et al ; Nietlispach, Fabian ; Maisano, Francesco

Abstract: **BACKGROUND** The impact of preexisting left bundle branch block (LBBB) in transcatheter aortic valve replacement (TAVR) recipients is unknown. The aim of this study was to determine the impact of preexisting LBBB on clinical outcomes after TAVR. **METHODS AND RESULTS** This multicenter study evaluated 3404 TAVR candidates according to the presence or absence of LBBB on baseline ECG. TAVR complications and causes of death were defined according to Valve Academic Research Consortium-2 definitions. Follow-up outpatient visits or telephone interviews were conducted at 30 days, 12 months, and yearly thereafter. Echocardiography examinations were performed at baseline, at hospital discharge, and at 1-year follow-up. Preexisting LBBB was present in 398 patients (11.7%) and was associated with an increased risk of permanent pacemaker implantation (PPI; 21.1% versus 14.8%; adjusted odds ratio, 1.51; 95% CI, 1.12-2.04) but not death (7.3% versus 5.5%; adjusted odds ratio, 1.33; 95% CI, 0.84-2.12) at 30 days. At a mean follow-up of 22±21 months, there were no differences between patients with and without preexisting LBBB in overall mortality (adjusted hazard ratio, 0.94; 95% CI, 0.75-1.18) and cardiovascular mortality (adjusted hazard ratio, 0.90; 95% CI, 0.68-1.21). In a subanalysis of 2421 patients without PPI at 30 days and with complete follow-up about the PPI, preexisting LBBB was not associated with an increased risk of PPI or sudden cardiac death. Patients with preexisting LBBB had a lower left ventricular ejection fraction (LVEF) at baseline and at 1-year follow-up ($P < 0.001$ for both), but those with low LVEF exhibited a similar increase in LVEF over time after TAVR compared with patients with no preexisting LBBB ($P = 0.327$). **CONCLUSIONS** Preexisting LBBB significantly increased the risk of early (but not late) PPI after TAVR, without any significant effect on overall mortality or cardiovascular mortality. Preexisting LBBB was associated with lower LVEF pre-TAVR but did not prevent an increase in LVEF post-TAVR similar to patients without LBBB.

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ORIGINAL ARTICLE

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See Editorial by Gulati and Wang

Quentin Fischer, MD et al

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CONCLUSIONS: Preexisting LBBB significantly increased the risk of early (but not late) PPI after TAVR, without any significant effect on overall mortality or cardiovascular mortality. Preexisting LBBB was associated with lower LVEF pre-TAVR but did not prevent an increase in LVEF post-TAVR similar to patients without LBBB.

The full author list is available on page 8.

Key Words: aortic valve ■ bundle-branch block ■ cause of death ■ echocardiography ■ follow-up studies ■ transcatheter aortic valve replacement

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WHAT IS KNOWN

- Preexisting right bundle branch block has been identified as the most important risk factor for permanent pacemaker implantation post-transcatheter aortic valve replacement, and some studies have shown an increased mortality risk among patients with preexisting right bundle branch block. However, no specific data exist on the impact of preexisting left bundle branch block on transcatheter aortic valve replacement outcomes.

WHAT THE STUDY ADDS

- In transcatheter aortic valve replacement recipients, preexisting left bundle branch block increases the risk of permanent pacemaker implantation but not mortality at 30 days.
- Preexisting left bundle branch block does not associate with increased mortality or heart failure hospitalization at 2-year follow-up, and most patients improve their left ventricular ejection fraction over time.

The prevalence of left bundle branch block (LBBB) is <1% in the general population but increases in case of underlying cardiomyopathy, as well as with age, from $\approx 0.5\%$ at 50 years to 5% at 80 years.¹ LBBB has been associated with an increased risk of adverse outcomes, including major cardiac events and mortality.^{2–4} Indeed, LBBB results in persistent asynchronous ventricular activation,⁵ which may lead to a redistribution of myocardial blood flow with septal hypoperfusion, left ventricular (LV) remodeling with ventricular dilatation, asymmetrical hypertrophy, mitral regurgitation, and reduction of LV ejection fraction (LVEF).^{6–8} This may become a vicious cycle with progressive LV failure, which often correlates with further progression of the conduction abnormality as well.

Transcatheter aortic valve replacement (TAVR) is a well-established therapy for patients with aortic stenosis and intermediate-to-prohibitive surgical risk.⁹ However, the occurrence of conduction disturbances and the need for permanent pacemaker implantation (PPI) remain the most frequent complications of TAVR.¹⁰ Preexisting right bundle branch block (RBBB) has been identified as the most important risk factor for PPI post-TAVR,¹⁰ and some studies have shown an increased mortality risk among patients with preexisting RBBB.^{11,12} However, no specific data exist on the impact of preexisting LBBB on TAVR outcomes. Therefore, the aim of this study was to evaluate the impact of preexisting LBBB on clinical outcomes in patients undergoing TAVR.

METHODS

Population

The data, analytic methods, and study materials will be available to other researchers for purposes of reproducing the results (the author for correspondence should be contacted for the data). A total of 4513 patients underwent TAVR in 18 centers between February 2005 and October 2017. Of these, 4434 patients with high-quality ECGs at baseline were included in the present analysis and grouped according to the presence of baseline complete LBBB. Patients with complete RBBB ($n=434$) or previous pacemaker ($n=596$) were excluded from the study, leading to a final study population of 3404 patients. Patients with incomplete LBBB were considered as no preexisting LBBB. TAVR indication, valve type, and approach were determined by each center's heart team. Clinical outcomes were defined according to the Valve Academic Research Consortium-2 definitions.¹³

Twelve-lead electrocardiographic tracings were recorded at baseline and at hospital discharge. Intraventricular conduction abnormalities were classified according to the American Heart Association, American College of Cardiology Foundation, and Heart Rhythm Society recommendations for standardization and interpretation of the ECG.¹⁴ PPI was mainly performed if third-degree or advanced second-degree atrioventricular block occurred at any anatomic level and was not expected to resolve or in the presence of sinus node dysfunction and documented symptomatic bradycardia, in agreement with current recommendations.¹⁵ However, the final indication for PPI was at the discretion of the physician responsible for the patient, with no prospective or centralized control about the decision and reasons for PPI. Therefore, the possibility of PPI out of current guideline recommendations in some cases cannot be excluded. Data were collected in accordance to the ethics committee of each participating center, and all patients provided signed informed consent for the procedures.

Follow-Up

Follow-up was undertaken by telephone and on-site clinical visit at 1 month, 1 year, and yearly thereafter. Follow-up was obtained in 97.2% of patients (94 patients, 2.8% of the study population, were lost to follow-up), and the mean follow-up was 22 ± 21 months. Complete follow-up about the time for PPI was obtained in a subgroup of 2564 patients (75.3%). Rate of complete follow-up was similar in both groups (77.1% in the LBBB group versus 75.1% in the no-LBBB group; $P=0.372$).

Complete echocardiography examinations were obtained at baseline (3349 patients; 98.4% of the population), at hospital discharge/1-month follow-up (2819 patients; 88.6% of patients alive at hospital discharge), and at 1-year follow-up (1689 patients; 58.0% of the patients at risk at 1-year follow-up). Changes in LVEF were analyzed in all patients with complete echocardiography at the 3 time points.

Outcomes

The primary outcomes of this analysis were (1) PPI and (2) cumulative all-cause mortality. Secondary outcomes were cardiovascular death, sudden cardiac death (SCD), and changes in LVEF over time. All outcomes were evaluated according to the

presence of baseline LBBB. Morphology of the QRS on baseline ECG was available in all patients. Methods used to assess causes of death were published previously.¹⁶ Cardiovascular death was defined according to Valve Academic Research Consortium-2 criteria. SCD was defined, in accordance with the World Health Organization definition, as a death occurring within 1 hour of symptom onset if witnessed or within the previous 24 hours if unwitnessed. Patients with known terminal disease or an identifiable noncardiac cause of sudden death were not considered to have experienced SCD.¹⁷

Statistical Analysis

Qualitative variables were expressed as number (percentage), whereas continuous data were presented as mean±SD or median (interquartile range) depending on their distribution. Survival rates were summarized using Kaplan-Meier estimates including all events ≤24-month follow-up, and log-rank tests were used to compare groups. Differences between groups in clinical outcomes were analyzed using a logistic regression (30-day outcomes) or Cox proportional-hazards models to adjust for baseline differences between groups. The variables included in the model were age, sex, atrial fibrillation, chronic kidney disease, LVEF <50%, and mean gradient. An ANOVA for repeated measures model with interaction was used to analyze the changes in LVEF over time. Posterior comparisons were performed using the Tukey post hoc test. All tests were 2 sided at the 0.05 significance level. Statistical analyses were conducted with the statistical package SAS, version 9.3 (SAS Institute, Cary, NC).

RESULTS

The main clinical characteristics, echocardiographic, and procedural findings of the study population are shown in Table 1. Patients in the LBBB group were older, had a higher operative risk, and a lower baseline LVEF ($P < 0.03$ for all). There were no differences between groups about the procedural findings, approach, and transcatheter valve type.

The 30-day outcomes according to preexisting LBBB are shown in Table 2. At 30 days, the mortality rate was similar in the preexisting LBBB and no-LBBB groups (7.3% versus 5.5%; adjusted odds ratio, 1.33; 95% CI, 0.84–2.12; $P = 0.217$). PPI occurred in 21.1% of patients with preexisting LBBB compared with 14.8% in the no-LBBB group (adjusted odds ratio, 1.51; 95% CI, 1.12–2.04; $P = 0.006$). At 30 days, no patient had a cardiac resynchronization therapy, and pacemaker type (single versus dual chamber) was similar in both groups (adjusted odds ratio, 1.08; 95% CI, 0.43–2.73; $P = 0.864$). The PPI rate was higher in those patients receiving a self-expandable valve (23.1% versus 8.7% for balloon-expandable valves; $P < 0.001$), as well as during the second (2012–2017) versus first (2005–2011) study time periods (16.9% versus 13.9%; $P = 0.015$). The rate of LBBB pre-TAVR was similar in the first and second study time periods (11.5% versus 12.0%; $P = 0.630$).

Table 1. Baseline and Procedural Findings of the Study Population, According to Preexisting LBBB

Variables	LBBB (n=398)	No LBBB (n=3006)	P Value
Baseline clinical characteristics			
Age, y	82.0±7.1	81.0±8.1	0.014
Men	218 (54.8)	1392 (46.3)	0.002
Body mass index, kg/m ²	26.5±5.0	26.7±5.1	0.452
Hypertension	302 (75.9)	2237 (75.1)	0.725
Diabetes mellitus	104 (26.1)	878 (29.4)	0.172
Atrial fibrillation	133 (33.9)	814 (27.8)	0.01
Previous cardiac surgery	97 (25.8)	624 (23.0)	0.226
Coronary artery disease	203 (51.0)	1438 (48.1)	0.275
Complete or no need for revascularization	278 (74.3)	2117 (75.3)	0.697
Chronic obstructive pulmonary disease	92 (23.1)	679 (22.8)	0.875
Chronic kidney disease (eGFR, <60 mL/min)	213 (56.2)	1444 (50.1)	0.026
Peripheral artery disease	75 (19.6)	529 (19.0)	0.794
STS score, %	6.2±4.0	5.5±3.2	0.024
Echocardiographic findings			
Left ventricular ejection fraction, %	48.8±16.3	56.9±12.9	<0.001
Left ventricular ejection fraction ≤50%	186 (48.4)	757 (25.8)	<0.001
Mean transaortic gradient, mm Hg	44.0±16.2	48.6±16.8	<0.001
sPAP>60 mm Hg	42 (14.9)	240 (11.8)	0.130
Procedural findings			
Primary access			0.626
Transfemoral	319 (80.2)	2444 (81.3)	
Subclavian	13 (3.3)	62 (2.1)	
Transapical	54 (13.6)	424 (14.1)	
Transaortic	7 (1.8)	40 (1.3)	
Valve type			0.355
Self-expandable	191 (48.1)	1369 (45.6)	
Balloon expandable	206 (51.9)	1630 (54.4)	
Implantation success (VARC-2)	336 (85.9)	2471 (83.4)	
Median length of stay, d (IQR)	7 (5–13.5)	7 (5–12)	0.347

eGFR indicates estimated glomerular filtration rate; IQR, interquartile range; LBBB, left bundle branch block; sPAP, systolic pulmonary artery pressure; STS, Society of Thoracic Surgeons; and VARC-2, Valve Academic Research Consortium-2.

In the no-LBBB group, a total of 2463 (72.4%) patients had a completely normal ventricular conduction, whereas 278 (9.2%), 10 (0.3%), 66 (2.2%), and 189 (6.3%) patients had a left anterior hemiblock, a left posterior hemiblock, an incomplete LBBB, and a nonspecific intraventricular conduction delay, respectively. The 30-day PPI rate was 14.3% in those patients with normal ventricular conduction versus 16.9% in

Table 2. Thirty-Day Outcomes, According to the Presence of Preexisting LBBB

Variables	LBBB (n=398)	No LBBB (n=3006)	OR (95% CI)	P Value	Adjusted OR (95% CI)	P Value
Death	29 (7.3)	165 (5.5)	1.43 (0.95–2.17)	0.089	1.33 (0.84–2.12)	0.217
Cardiovascular death	25 (6.3)	141 (4.7)	1.44 (0.93–2.25)	0.106	1.39 (0.85–2.27)	0.189
Stroke	16 (4.0)	105 (3.5)	1.15 (0.67–1.97)	0.619	0.85 (0.45–1.62)	0.633
Myocardial infarction	7 (1.8)	36 (1.2)	1.61 (0.70–3.68)	0.263	1.27 (0.50–3.19)	0.618
Major or life-threatening bleeding event	60 (15.1)	413 (13.8)	1.26 (0.93–1.70)	0.135	1.35 (0.98–1.86)	0.067
New pacemaker	84 (21.1)	445 (14.8)	1.37 (1.04–1.81)	0.023	1.51 (1.12–2.04)	0.006
Moderate or severe aortic regurgitation	37 (10.8)	282 (10.8)	0.92 (0.63–1.34)	0.668	0.81 (0.53–1.23)	0.322

LBBB indicates left bundle branch block; and OR, odds ratio.

patients with left anterior hemiblock ($P=0.249$), 20.0% in patients with a left posterior hemiblock ($P=0.610$), 16.7% in patients with an incomplete LBBB ($P=0.594$), and 14.4% in patients with a nonspecific intraventricular conduction delay ($P=0.991$).

Late Clinical Outcomes

At a mean follow-up of 22 ± 21 months, 914 patients (26.9%) had died. Cardiovascular death occurred in 573 patients (16.8%), including heart failure (HF) death in 154 patients (4.5%) and SCD in 84 patients (2.5%). Late clinical events post-TAVR grouped according to preexisting LBBB are shown in Table 3. There were no differences between groups in late all-cause mortality (adjusted hazard ratio, 0.84; 95% CI, 0.64–1.08; $P=0.173$) or cardiovascular mortality (adjusted hazard ratio, 0.74; 95% CI, 0.51–1.05; $P=0.093$). The Kaplan-Meier curves for clinical

events (mortality, cardiovascular mortality, and hospitalization for HF) ≤ 2 -year follow-up are shown in Figure 1.

The cumulative rate of PPI was higher in the preexisting LBBB group (22.9% versus 16.5%; hazard ratio, 1.40; 95% CI, 1.11–1.78; $P=0.006$). However, this was because of an increased PPI rate early after TAVR (median time of PPI, 4 [interquartile range, 1–7] days), and no differences between groups were observed in the PPI rate after the first 30 days post-TAVR (preexisting LBBB, 2.2%; no preexisting LBBB, 1.9%; adjusted hazard ratio, 0.95; 95% CI, 0.45–2.03; $P=0.904$). The Kaplan-Meier curves for PPI and SCD are shown in Figure 2. There were no differences in late (>30 days) sudden death or PPI between groups.

LVEF Changes After TAVR

Patients in the preexisting LBBB group had a baseline LVEF significantly lower than patients with no preexisting

Table 3. Late Outcomes After TAVR, According to the Presence of Preexisting LBBB

Variables	LBBB (n=398)	No LBBB (n=3006)	HR (95% CI)	P Value	Adjusted HR (95% CI)	P Value
Late outcomes (>30 d)*						
Death	79 (21.4)	641 (22.6)	0.91 (0.71–1.16)	0.431	0.84 (0.64–1.08)	0.173
Cardiovascular death	43 (11.5)	364 (12.7)	0.86 (0.62–1.20)	0.384	0.74 (0.51–1.05)	0.093
Stroke	6 (1.6)	44 (1.5)	1.09 (0.43–2.77)	0.863	1.15 (0.41–3.24)	0.789
Myocardial infarction	0	12 (0.4)
New pacemaker	7 (2.2)	50 (1.9)	1.22 (0.53–2.79)	0.642	0.95 (0.45–2.03)	0.904
Hospitalization for HF	39 (10.1)	239 (8.2)	1.20 (0.84–1.70)	0.319	1.07 (0.74–1.55)	0.706
Cumulative outcomes†						
Death	108 (27.1)	806 (26.8)	1.01 (0.81–1.24)	0.978	0.94 (0.75–1.18)	0.596
Cardiovascular death	68 (17.1)	505 (16.8)	1.01 (0.78–1.32)	0.938	0.90 (0.68–1.21)	0.509
Stroke	22 (5.5)	149 (4.9)	1.16 (0.73–1.82)	0.533	1.09 (0.68–1.76)	0.735
Myocardial infarction	7 (1.8)	48 (1.6)	1.20 (0.55–2.62)	0.650	1.16 (0.52–2.64)	0.713
New pacemaker	91 (22.9)	495 (16.5)	1.41 (1.12–1.78)	0.004	1.40 (1.11–1.78)	0.006
Hospitalization for HF	52 (13.1)	320 (10.7)	1.20 (0.89–1.62)	0.243	1.05 (0.76–1.44)	0.785

LBBB indicates left bundle branch block; HF, heart failure; HR, hazard ratio; and TAVR, transcatheter aortic valve replacement.

*Late outcomes were defined by outcomes occurring after the first 30 d post-TAVR. Patients whose events occurred before 30 d were excluded of this analysis.

†Cumulative outcomes were showed without time censure.

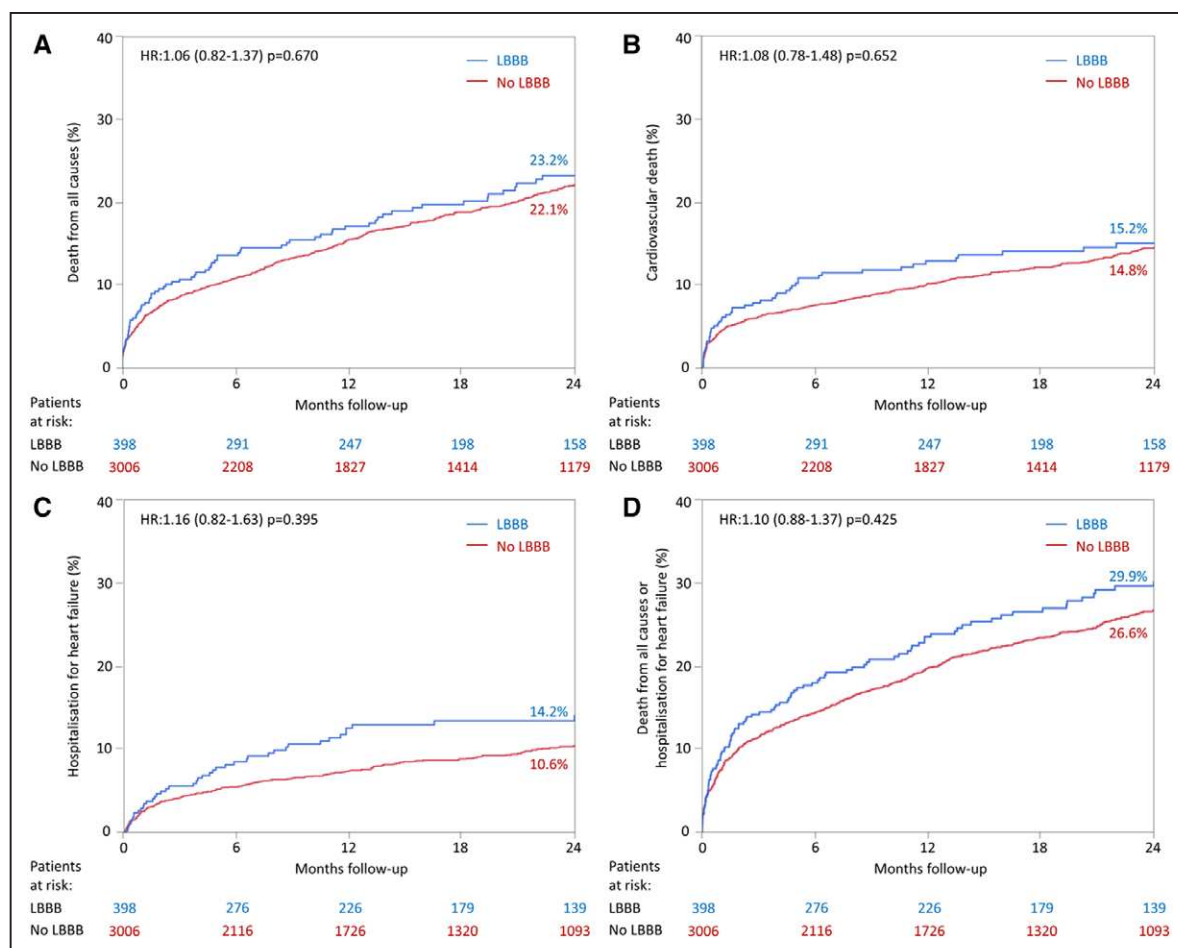


Figure 1. Clinical events at 2-y follow-up, according to preexisting left bundle branch block (LBBB).

A, Kaplan-Meier curves at 2-y follow-up for overall mortality according to the presence of preexisting LBBB. **B**, Kaplan-Meier curves at 2-y follow-up for cardiovascular mortality according to the presence of preexisting LBBB. **C**, Kaplan-Meier curves at 2-y follow-up for hospitalization for heart failure according to the presence of preexisting LBBB. **D**, Kaplan-Meier curves at 2-y follow-up for overall mortality or hospitalization for heart failure according to the presence of preexisting LBBB. HR indicates hazard ratio.

LBBB ($48.4 \pm 0.8\%$ versus $57.0 \pm 0.2\%$; $P < 0.001$). At discharge, LVEF increased in both groups ($51.3 \pm 0.8\%$ in the preexisting LBBB group, $\Delta +2.9 \pm 0.7\%$ versus $58.4 \pm 0.2\%$ in the no preexisting LBBB group, $\Delta +1.4 \pm 0.2\%$). LVEF continued to increase in both groups during follow-up (at 12-month follow-up: $52.6 \pm 0.9\%$ in the preexisting LBBB group, $\Delta +4.2 \pm 0.9\%$ versus $59.1 \pm 0.3\%$ in the no preexisting LBBB, $\Delta +2.0 \pm 0.3\%$). Despite a lower LVEF in the preexisting LBBB group, the relative increase of the LVEF 1 year post-TAVR was not significantly different between the 2 groups ($P = 0.085$; Figure 3A). Likewise, among patients with baseline LVEF $\leq 50\%$, LVEF increased from $38.8 \pm 0.4\%$ at baseline to $46.2 \pm 0.6\%$ at hospital discharge ($\Delta +7.4 \pm 0.4\%$) and reached $50.2 \pm 0.6\%$ 1 year after TAVR ($\Delta +11.4 \pm 0.6\%$). LVEF increased in both groups at discharge ($42.0 \pm 1.1\%$ in the preexisting LBBB group, $\Delta +7.3 \pm 0.9\%$ versus $47.4 \pm 0.6\%$ in the no preexisting LBBB group, $\Delta +7.4 \pm 0.5\%$) and continued to increase in both groups during follow-up ($45.6 \pm 1.3\%$ in the preexisting LBBB group, $\Delta +10.9 \pm 1.3\%$ versus $51.6 \pm 0.6\%$ in the no preexisting LBBB group at 1 year,

$\Delta +11.5 \pm 0.6\%$; Figure 3B). Among patients with baseline LVEF $< 50\%$, similar changes in LVEF over time were observed in the preexisting LBBB and no preexisting LBBB groups ($P = 0.327$).

DISCUSSION

In patients undergoing TAVR, preexisting LBBB was associated with an increased risk of PPI but not mortality at 30 days. Preexisting LBBB had no deleterious effect on late outcomes, including overall and cardiovascular mortality. Patients with preexisting LBBB exhibited a lower LVEF pre-TAVR but experienced a similar degree of increase in LVEF at 1-year follow-up compared with those patients with no significant conduction disturbances pre-TAVR.

Previous studies have shown a prevalence of LBBB in TAVR candidates close to 10%,^{12,16,18} and the slightly higher rate observed in our study ($\approx 12\%$) may be related to the exclusion of patients with other conduction abnormalities, such as RBBB or those with prior

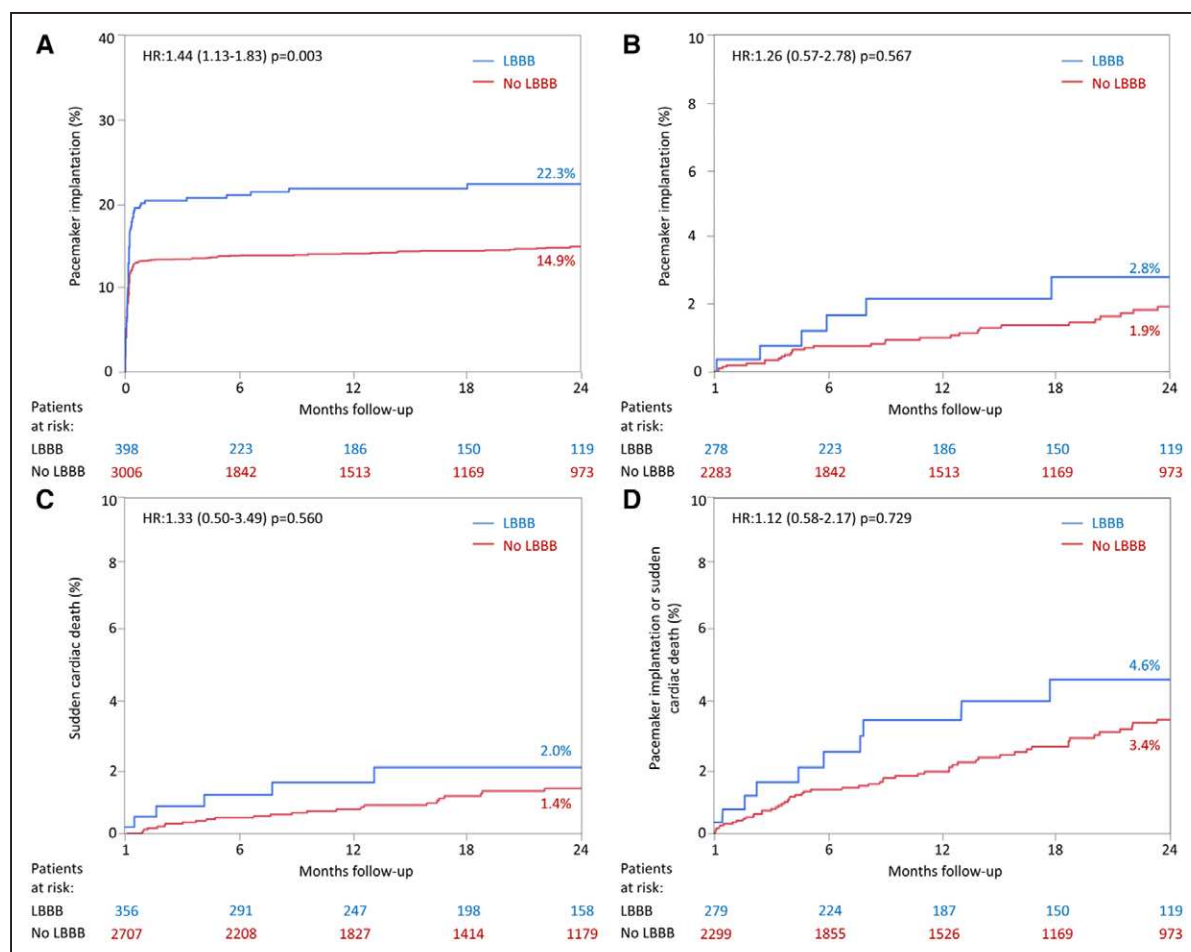


Figure 2. Permanent pacemaker implantation and sudden cardiac death at 2-y follow-up, according to preexisting left bundle branch block (LBBB).

A, Kaplan-Meier curves at 2-y follow-up for permanent pacemaker implantation (PPI) according to the presence of preexisting LBBB. **B**, Kaplan-Meier curves for PPI between 30 d and 2 y according to the presence of preexisting LBBB in patients with no PPI at 30-d follow-up. **C**, Kaplan-Meier curves for sudden cardiac death (SCD) between 30 d and 2 y according to the presence of preexisting LBBB in patients with no PPI at 30-d follow-up. **D**, Kaplan-Meier curves for SCD or PPI between 30 d and 2 y according to the presence of preexisting LBBB in patients with no PPI at 30-d follow-up. HR indicates hazard ratio.

pacemaker. The development of ventricular conduction disorders, particularly LBBB, can result from either intrinsic conduction system degeneration or an extrinsic insult from a variety of cardiovascular diseases.¹⁹ Several factors have been associated with LBBB development, including LV hypertrophy, increased cardiac volume, hypertension, valvular heart disease, cardiomyopathies, myocarditis, and coronary artery disease.^{20,21} Most patients with severe aortic stenosis have many of these risk factors, and this may explain the higher rate of LBBB in this population compared with the general population.

The rates of PPI after TAVR are highly variable but average 13%,¹⁰ and no significant decrease in the incidence of PPI has been observed in the past years, despite the increasing experience of centers/operators and the use of newer generation valve systems.^{10,22} Multiple risk factors have been identified as independent predictors for PPI post-TAVR, like valve type, LV outflow tract calcium load, implantation depth, or preexisting RBBB.^{10,23} The His bundle bifurcates into the

right and left bundles at the inferior border of the membranous septum, with the latter emerging beneath the noncoronary cusp. Therefore, valve implantation that overlaps the distal membranous septum may affect both the right and left bundles and lead to complete heart block. Electrophysiological studies showed that aortic valve implantation increases the risk of conduction disturbances, most likely by increasing the His-ventricle interval or inducing an infra-Hisian block.²⁴ Our study was the first to highlight that baseline LBBB significantly increases the risk of PPI after TAVR. Importantly, the increased risk occurred early after TAVR, probably secondary to the mechanical compression of the His bundle during valve implantation, and no significant increase in the rate of late PPI or SCD was observed at 2-year follow-up. This provides some reassurance about the management of these patients in the absence of advanced conduction disturbances during the hospitalization period and contrasts with the results observed in the presence of new-onset LBBB post-TAVR, which seems to determine an increased risk of PPI and SCD within

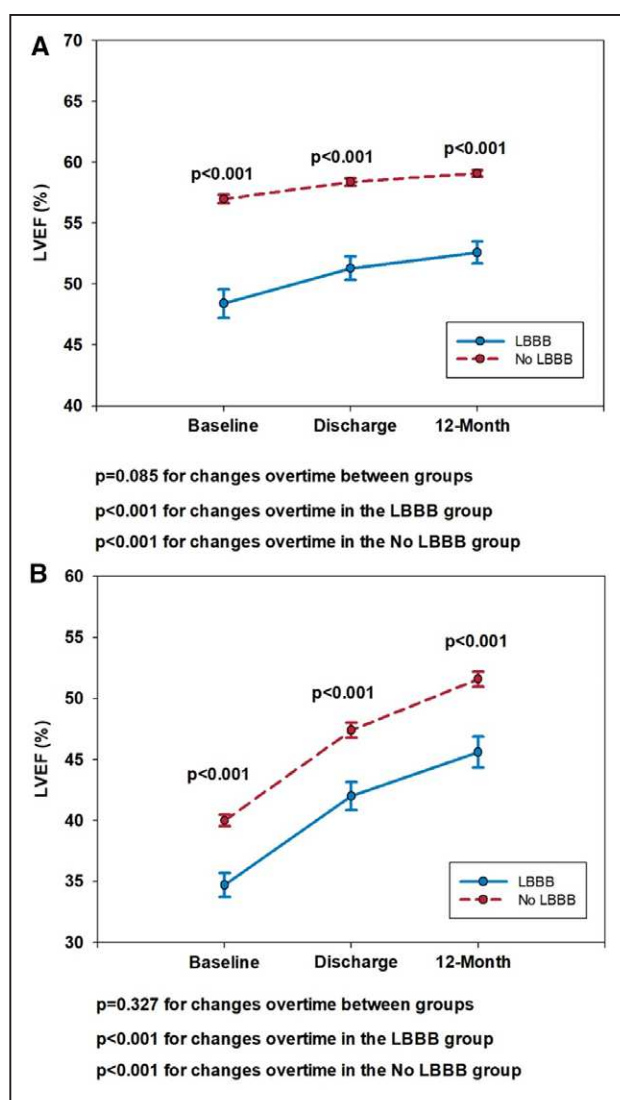


Figure 3. Changes in left ventricular ejection fraction (LVEF) after transcatheter aortic valve replacement (TAVR), according to preexisting left bundle branch block (LBBB).

A, LVEF changes over time in overall population. **B,** LVEF changes over time after TAVR in patients with LVEF <50% at baseline.

the months after the procedure.^{10,16,25} Interestingly, the presence of preexisting LBBB has already been identified as an important risk factor for PPI after surgical aortic valve replacement.²⁶ These results should be taken into account in the preparation of the TAVR procedures, considering the use of a valve type associated with a lower risk of conduction disturbance issues and a high (more aortic) transcatheter valve positioning in those patients with preexisting LBBB, to decrease the PPI after TAVR.

Several studies in nonaortic stenosis populations have shown the negative effects of LBBB on long-term (≥ 10 years) outcomes, particularly in elderly patients and in the presence of underlying heart disease.^{27–33} The lack of increase in mortality risk at 2-year follow-up in our study may be because of the positive effects related to the treatment of aortic stenosis and the increase in the LVEF post-TAVR along with the shorter follow-up

compared with prior studies in the general population and in patients with other cardiomyopathies. A continuous follow-up of such patients will be important in determining the impact of preexisting LBBB on longer term clinical outcomes post-TAVR.

In patients with HF and reduced LVEF, LBBB is associated with an increased incidence of sudden death, all-cause mortality, and acute HF.^{34–36} In contrast, we failed to find an increase in the rate of hospitalizations for HF among TAVR recipients with preexisting LBBB, despite a lower LVEF in this group. This could be partially explained by a similar improvement in LV function in patients with and without preexisting LBBB within the months after TAVR. Unlike other studies in patients with other cardiac diseases, even those patients with LBBB and reduced LVEF at inclusion experienced similar improvement in LVEF than patients without LBBB during follow-up. A recent study found that patients with LBBB and mild-to-moderate LV dysfunction (LVEF between 36% and 50%) have exceedingly poor outcomes. At 5 years, 59% of patients had died, further decreased their LVEF $\leq 35\%$, had a sustained ventricular arrhythmia, or required device implantation.³⁷ LBBB results in dysynchronous electrical activation of the ventricles and inefficient contraction of the LV and may lead to progressive LV failure. This process may be disrupted by cardiac resynchronization therapy, and the indication for resynchronization should be evaluated in patients with complete LBBB and persistent LVEF $\leq 35\%$ after TAVR. However, the results of the present study showing significant improvements in LVEF in a high proportion of patients strongly suggest that this evaluation should not be performed immediately but several months after the TAVR procedure.

Study Limitations

Given the nonrandomized nature of the study, the presence of unmeasured confounders that may influence the relationship between LBBB and outcomes cannot be excluded.

Although the causes of death at each center were defined according to the Valve Academic Research Consortium-2 criteria, no event adjudication committee was available in this study. Electrocardiographic and echocardiographic findings were interpreted at each center, with no electrocardiographic or echocardiographic core laboratory evaluation. Depth of implant, degree of LV outflow tract calcification, and duration of the PR interval on baseline ECG were not available in most patients, precluding an analysis of the impact of these factors in PPI rates. In addition, echocardiographic data at 1-year follow-up were available in $\approx 60\%$ of patients. Data about the use of atrioventricular node-blocking medications, which may affect the PPI, were not available. Finally, the indication for PPI during follow-up was not collected in all centers.

Conclusions

The results of this study show that preexisting LBBB increased the risk for PPI early post-TAVR. However, preexisting LBBB in TAVR recipients was not associated with increased mortality or HF hospitalization at 2-year follow-up, and there were significant improvements in LVEF in most patients. This suggests that the possible use of specific therapies, including cardiac resynchronization therapy, should be delayed by several months to avoid implementing unnecessary treatment. Future studies should determine the longer term outcomes of such patients.

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Authors

Quentin Fischer, MD; Dominique Himbert, MD; John G. Webb, MD; Helene Eltchaninoff, MD; Antonio J. Muñoz-García, MD, PhD; Corrado Tamburino, MD, PhD; Luis Nombela-Franco, MD, PhD; Fabian Nietlispach, MD, PhD; Cesar Moris, MD, PhD; Marc Ruel, MD; Antonio E. Dager, MD; Vicenç Serra, MD; Asim N. Cheema, MD; Ignacio J. Amat-Santos, MD, PhD; Fabio Sandoli de Brito, MD; Henrique Ribeiro, MD, PhD; Alexandre Abizaid, MD; Rogério Sarmiento-Leite, MD; Eric Dumont, MD; Marco Barbanti, MD; Eric Durand, MD, PhD; Juan H. Alonso Briaes, MD; Claire Bouleti, MD, PhD; Sebastiano Immè, MD; Francesco Maisano, MD; Raquel del Valle, MD; Luis Miguel Benitez, MD; Bruno García del Blanco, MD; Mélanie Côté, MSc; François Philippon, MD, FRCPC, FHRS; Marina Urena, MD, PhD; Josep Rodés-Cabau, MD

Correspondence

Josep Rodés-Cabau, MD, Quebec Heart and Lung Institute, Laval University, 2725 Chemin Ste-Foy, G1V 4G5, Quebec City, Quebec, Canada. Email josep.rodés@criucpq.ulaval.ca

Affiliations

Department of Cardiology, Quebec Heart and Lung Institute, Laval University, Canada (Q.F., E.D., M.C., F.P., J.R.-C.). Department of Cardiology, Assistance Publique-Hôpitaux de Paris, Bichat Hospital, France (D.H., C.B., M.U.). Department of Cardiology, St. Paul's Hospital, Vancouver, British Columbia, Canada (J.G.W., M.B.). Department of Cardiology, Hôpital Charles Nicolle, University of Rouen, France (H.E., E.D.). Department of Cardiology, Hospital Universitario Virgen de la Victoria, Universidad de Málaga, Spain (A.J.M.-G., J.H.A.B.). Department of Cardiology, Ferrarotto Hospital, University of Catania, Italy (C.T., M.B., S.I.). Instituto Cardiovascular, Hospital Clinico San Carlos, IdISSC, Madrid, Spain (L.N.-F.). Department of Cardiology, University Heart Center, Transcatheter Valve Clinic, Zurich, Switzerland (F.N., F.M.). Department of Cardiology, Hospital Universitario Central de Asturias, Oviedo, Spain (C.M., R.d.V.). Department of Cardiology, Ottawa Heart Institute, University of Ottawa, Ontario, Canada (M.R.). Department of Cardiology, Clinica de Occidente de Cali, Colombia (A.E.D., L.M.B.). Department of Cardiology, Hospital Universitari Vall d'Hebron, Barcelona, Spain (V.S., B.G.d.B.). Department of Cardiology, St. Michael's Hospital, Toronto University, Ontario, Canada (A.N.C.). Department of Cardiology, Hospital Clinico Universitario de Valladolid, Spain (I.J.A.-S.). Department of Cardiology, Hospital Israelita Albert Einstein, São Paulo, Brazil (F.S.d.B.). Department of Cardiology, Heart Institute-InCor, University of São Paulo, Brazil (H.R.). Department of Cardiology, Instituto Dante Pazzanese de Cardiologia, São Paulo, Brazil (A.A.). Department of Cardiology, Instituto de Cardiologia do Rio Grande do Sul, Porto Alegre, Brazil (R.S.-L.).

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